

CHRYSANTHEMUM WHITE RUST: A NATIONAL MANAGEMENT PLAN FOR EXCLUSION AND ERADICATION.

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Introduction:

Puccinia horiana Henn., a filamentous fungus and obligate parasite, is the causal agent of chrysanthemum white rust (CWR). The need to revise the Western Region's present CWR Program and expand it to the national level has been generally accepted by those involved in the program. CWR has been identified in regulated occurrences in the past, and in all cases the disease has been successfully eradicated. The eradication protocols are based on the disease eradication efforts in the United States, Canada and United Kingdom (1, 2 and 5). It is believed that successful eradication of CWR, whenever it has found, has saved the industry large sums of money. For more information regarding the pathogen's history, biology, disease symptoms, hosts, transmission and other characteristics, please, refer to the Background section of this document.

The eradication of CWR disease is feasible in the light of the following salient characteristics of the pathogen:

- * *P. horiana* has a limited host range,
- * the fungal spores have a relatively short survival time,
- * *P. horiana* has a poor dispersal mechanism, and
- * this pathogen can survive only in a green host tissue.

The following recommendations are based on the following elements:

- * CWR is a pest of quarantine significance in the United States (Title 7, Code of Federal Regulations (CFR) - January 1, 2002 - Part Q 319.37-2 (a), pp. 220 & 222) requiring appropriate quarantine action when found. CWR is not established in the United States, nor are transitory outbreaks widespread.
- * APHIS must continue to maintain the CWR program both in the interior and at the ports of entry.
- * Quarantine action needs to be applied uniformly whenever CWR is found.
- * All quarantine actions taken are directed toward eradication.

- Port of Entry inspections:

CWR is a pest of quarantine significance (Ref: 7CFR - 2002, Part Q 319.37-2 (a), pp. 220 & 222). As such, all propagative and non propagative (cut flowers) chrysanthemum material arriving at the U.S. ports will be very carefully inspected for the presence of CWR. An appropriate and immediate action will be taken to destroy any infected plant material showing CWR symptoms.

- Nursery survey:

All nurseries handling chrysanthemum material should be periodically surveyed for CWR. Most states presently conduct routine nursery inspections. State Inspections of nurseries handling chrysanthemums should be timed to coincide with the period when CWR is most likely to manifest itself. In areas where CWR has been known to occur, it is recommended that two surveys be conducted per year by trained personnel and timed to coincide with the period of symptom expression. In addition, circumstances may dictate a need for increased surveillance of producers of propagative material. Such producers must make use of the fungicidal dip treatment of chrysanthemum cuttings before planting them as a curative or preventive measure for CWR (1).

- Infected Nurseries:

Should a nursery be found to be infected, both a State and Federal Emergency Action Notice (EAN) should be issued against the nursery. This EAN will remain in place until the nursery has satisfactorily completed the following sanitation measures. When multiple and/or frequent CWR infections are found in a given area, a quarantine of the area should be considered.

A. Localized Infection: If it is determined that the infection is localized (less than 50% plants showing symptoms of infection) within a facility, all the infected plants showing symptoms and all plants extending out at least 1 meter radius of the infected plant/s will be destroyed. The remaining plants must submit to the following treatment schedule:

Three treatments of myclobutanil (a systemic fungicide with protectant and curative properties), or another appropriate fungicide [e.g., Heritage, Daconil Ultrex or Medallion (fludioxonil)] applied at 5 - 7 day (preferably 5 day) intervals with 100% inspections between the treatments to confirm for the freedom of CWR symptoms. If additional infection between the 3 treatments is detected, destroy all infected plants showing symptoms and all plants extending out 1 meter radius of the infected plant/s. Plants may be released only after all 3 applications of the fungicide including 100% inspections between the treatments are completed and one final inspection at the end of the treatments which reveals no visible symptoms of CWR.

Plants grown for ultimate use as cut flowers must also be submitted to three treatments of myclobutanil, but the cut flowers themselves may be released following the first application and one inspection if no symptoms of CWR are visible. Other mitigating measures may be taken as appropriate. All plants that are not removed from the premises then should be treated according to the 5 - 7 day interval treatment schedule. A final inspection must be made to verify freedom of CWR symptoms before release of plants.

The three-treatment protocol is supported by USDA/ARS, USDA/ APHIS, the National Plant Board, Departments of Agriculture in California, Oregon, Washington, Florida, and Ohio. The protocol of three treatments of Mycobutanil with 100% inspection was determined to be adequate and efficacious in one localized incidence of CWR in California in 2001.

B. Generalized Infection: If it is determined that the infection is generalized (more than 50% plants showing symptoms of infection) within a facility, all chrysanthemum plants in the infected production area or on the property will be destroyed and the property will remain host free for eight weeks, or be treated in a manner approved by the State and USDA/APHIS.

One such treatment option, as an alternative to the 8 week host-free period, is **steam treatment** of the nursery beds using steam jet method. Soil must be steamed at 70°C for a minimum 30 minutes and to a depth of 15 cm. Temperature must be measured at points farthest from the source of steam. Steam at a temperature of 70°C will destroy most pathogenic microorganisms including CWR spores or their common vegetative forms, either in the growing or vegetative state. Moist soil conditions reduce the duration of teliospore survival, so soil in plots or beds should be kept well watered during the preplanting interval to aid in destruction of any residual inoculum. The beds must be inspected by a State and/or USDA/APHIS official to ensure efficacy of steam treatment i.e. all green plant material has been destroyed. Repeat steam treatment after 48 h to destroy any newly developed, germinating or remaining fungal spores.

- A Door yard survey:

It is recommended that a modified 400 m delimiting survey be conducted around each infected nursery. This survey can be conducted by walking through and carefully examining the survey area. The objective is to locate any obvious planting of chrysanthemums in the area and to inspect these chrysanthemums for the symptoms of CWR to determine if they could have been the source of the infection. This survey should take no longer than one day. Should the same nursery be found to be infected two years in a row, a more thorough survey of up to 800 m should be considered. In addition, personnel involved in other survey activities, such as gypsy moth trapping, should be trained and encouraged to look for CWR symptoms while performing their duties. Survey results must be added to the National Agricultural Pest Information System (NAPIS) database.

- Trace Back:

Infected material will be traced both back to its origin, and forward to receiving destinations. It should be done in case of both localized and generalized infections. All commercial establishments where potentially infected material has been sent and/or received will be inspected for the presence of CWR.

Under this program nurseries will be informed and encouraged to incorporate appropriate cultural practices, sanitation measures, inspection protocols, maintenance schedules, appropriate treatments, record-keeping, and other administrative suggestions in order to assure that propagative chrysanthemum nursery stock produced is free of CWR. Should a trace back (or forward) of a CWR infection implicate a particular nursery, a survey of this nursery and a review of the records will be conducted. If everything is in order, no additional work (trace forward or back) will be necessary.

- Research:

With appropriate funding, a research program could be initiated to help determine the source/cause (pathway) of new infections. Development and use of CWR resistant varieties and innovative detection methods are needed. Also, training workshops could familiarize Federal and State regulatory officials, and chrysanthemum growers, propagators or producers with the symptoms of CWR. Trained personnel could contribute to a warning system that would alert chrysanthemum growers to susceptible periods.

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Background:

Pathogen/Disease: *Puccinia horiana* Henn., a filamentous fungus and obligate parasite, is the causal agent of chrysanthemum white rust (CWR). CWR is a serious disease in nurseries where it may cause complete loss of glasshouse chrysanthemum crops. The disease is indigenous to Japan where it was noted in 1895, and it remained confined to China and Japan until 1963. However, since 1964, *P. horiana* has spread rapidly on infected imported cuttings and is now established in Europe, Africa, Australia, Central America, South America and the Far East (2, 6).

CWR is not established in the United States, nor are transitory outbreaks widespread. Under the Plant Protection Act of 2000, CWR is a disease of quarantine significance in the United States (Title 7, Code of Federal Regulations (CFR) - Part Q 319.37-2 (a). This disease has the

potential to be extremely damaging to the commercial horticulture and florist industries if it becomes established in the United States. Therefore, the importation of chrysanthemum species is prohibited from several countries, territories, and possessions. Whenever CWR has

been detected in the U.S., it has been eradicated through immediate and cooperative regulatory action by Federal and State officials.

Based on the definitions given in the Food and Agriculture Organization of the United Nations' Publication No. 8 (Rome, 1999) on International Standards for Phytosanitary Measures for the Determination of Pest Status in an Area (4), when CWR is found in the United States, it fits under the category of, "Transient: actionable, under eradication". The explanation of this category given in the publication is that "the pest has been detected as an isolated population which may survive into the immediate future and, without phytosanitary measures for eradication, may establish. Appropriate phytosanitary measures have been applied for its eradication." Otherwise, CWR is not present in the US.

Hosts: In a recent taxonomic revision, the plants belonging to the former *Chrysanthemum* spp. complex have been transferred to several other genera. Only three species are now recognized as belonging in the genus *Chrysanthemum*. They are *C. carinatum*, *C. coronarium*, and *C. segetum*. They are annuals native to the Mediterranean area, and recent susceptibility tests show that they are not hosts to CWR. However, susceptibility has been documented in *Dendranthema* spp. (florist's mum, florist chrysanthemum, cultivated mum), *Nipponanthemum* spp. (Nippon Daisy, Nippon-chrysanthemum), *Leucanthemella* spp. (high daisy, giant-daisy), and *Ajania pacifica* (*Ajania* is monotypic).

The nursery stock regulation (7CFR 319.37) has listed *Dendranthema* as a host of CWR for several years. Twelve species of chrysanthemum (*Dendranthema*) are known to be hosts for CWR. The restrictions that apply to *Dendranthema* also apply to vegetative propagules of *Ajania*, *Leucanthemella* and *Nipponanthemum*. The common name "chrysanthemum" should be associated with entries for the four aforementioned genera, but not with entries of *Chrysanthemum* spp. Genera other than *Chrysanthemum* that have not shown susceptibility to CWR (e.g., *Argyranthemum*, *Leucanthemum*, etc.) are admissible with a permit subject to inspection (5).

Biology and Ecology: *P. horiana* is an autoecious rust. The bicellular teliospores germinate *in situ* to produce unicellular basidiospores which are dispersed in air currents. No other spores are known. High humidity and a film of moisture appear to be necessary for the germination of both teliospores and basidiospores. Teliospores are capable of germination as soon as they are mature. Germination and discharge of basidiospores occur between 4 and 23°C and, at the optimum temperature of 17°C and in moist conditions of 96% to 100% relative humidity, basidiospores discharge starts within 3 h. Basidiospores also can travel short distances (700 meters) by wind currents during moist weather. Basidiospores can germinate over a wide temperature range and, at 17-24°C, either surface of the leaf may be penetrated within 2 h. Thus, only 5 h of wetness is sufficient for a new infection to become established.

Basidiospores can cause an epidemic if conditions are right. They spread from plant to plant by splashing water and they must have a film of water on the plant surface for infection. Within the leaf, abundant, hyaline, intercellular hyphae are produced with intracellular haustoria (2).

Symptoms: CWR can be recognized by the small pale green to yellow spots, up to 4-5 mm wide, on the upper leaf surface. Spore forming pustules (telia) form on the lower leaf surface,

beneath the small spots. These pustules are buff to pink-colored but become quite prominent and turn whitish when basidiospores are produced. As the disease advances, the spots on the upper surface become sunken, turn brown and become necrotic. CWR pustules are most common on young leaves and flower bracts but can be found on any green tissue and flowers. Severely attacked leaves wilt, hang down the stem, and gradually dry up. Infected plants do not always express symptoms during hot and dry conditions. Symptoms usually appear during cooler, wet weather. Normally, symptoms develop within 5 to 14 days after initial infection. The fungus itself will only grow and reproduce on susceptible plants and will not develop outside the plant.

Disease Transmission: The disease normally is carried on infected cuttings and plants (including cut flowers) of glasshouse chrysanthemums (1, 3, 6 and 7). Infections occur when infected cuttings or viable spores are brought into a greenhouse, thereby exposing the uninfected cuttings or plants to inoculum. Infected cuttings may appear normal even though the fungus is present. Following the production of pustules on the surface of leaves, the disease is transmitted from infected stock to healthy plants primarily by splashing water that contains spores. Free water on the leaves is necessary for spore development. As explained earlier, under optimal conditions, new infection can be established in as little as 5 h. CWR basidiospores can travel 400 m under high humidity conditions or during a rain storm. There are reports that dispersal by wind can occur over distances of 700 m and more but, because the basidiospores are very sensitive to desiccation at less than 90% RH, long-distance spread would be likely only during very wet periods. **Natural spread is hence unlikely over long distances; it is limited even between glasshouses** (otherwise it would never have been possible to contain the disease at all).

CWR also can be spread to uninfected plants on contaminated soil, litter, dead leaves, gardening equipment, clothes, shoes and hands. The ability of the fungus to overwinter outdoors is unknown. In experiments, teliospores in pustules on detached leaves survived for 8 weeks at 50% relative humidity or less but, at higher humidities or when buried in dry or moist compost, they only survived for 3 weeks or less. Basidiospores survive 5 minutes when the relative humidity is 80% or less, and up to 60 minutes when the relative humidity is 81 to 90%. The basidiospores are fragile and under normal conditions generally can not survive longer than about 1 h. **It therefore appears that infected debris is not likely to be important in the carry-over of the disease.** Some chrysanthemum cultivars appear to be more susceptible than others, and there is evidence that pathotypes of the fungus exist. Consequently, there are continuous efforts to breed for new chrysanthemum cultivars resistant to CWR (2).

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Attachment:

The following is the list of members of the CWR's National Review Team (NRT), for the preparation of CWR National Management Plan for Exclusion and Eradication of CWR (the Plan), including their affiliation, telephone numbers and E-mail addresses. Each and every member of the CWR's NRT was contacted and given an opportunity to review and provide comments and input on the draft of Questions and Issues related to CWR in order to prepare the Plan.

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